Reprinted from *1997 Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 977,* pp. 16-19, 1997
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

# BIOSOLIDS IN COLUMBIA BASIN DRYLAND CROPPING SYSTEMS

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## INTRODUCTION

This report introduces the rationale and some preliminary data from a new project with biosolids (digested sewage sludge) in Sherman County.

Biosolids are a byproduct of municipal wastewater treatment. Biosolids have been successfully land-applied for over 20 years in Oregon (Sullivan, 1996). Recent developments affecting biosolids utilization in Oregon include:

1. Current “heavy metal” concentrations in biosolids (cadmium, zinc, copper etc.) are much lower than 20 years ago, due to consistent enforcement of industrial wastewater quality standards. Current metal concentrations are far below those necessary for human and environmental safety (USEPA, 1993; National Academy of Sciences, 1996).

2. Improved biosolids processing technologies have increased solids content and product value (3 to 5 times higher nutrient value per unit weight).

3. Current economics make long-distance transport an economical alternative to winter storage for western Oregon wastewater treatment facilities.

4. Most western Oregon cities have experienced large increases in biosolids production, due to more sewer hook-ups and improved wastewater treatment processes. For many facilities, biosolids production has doubled over the last 10 to 15 years.

These developments have led to increased interest among central and eastern Oregon growers and western Oregon municipalities in working together to utilize biosolids. Biosolids are an inexpensive form of nitrogen (N), and growers perceive potential additional benefits from the organic matter in biosolids. From the environmental point of view, advantages to using biosolids in a wheat-fallow cropping system include:

1. There is little opportunity for biosolids runoff or public contact with biosolids after application.

2. Wheat and other cereals largely exclude metals like zinc and cadmium from the grain. There is little change in grain metal concentrations with agronomic biosolids application rates.

3. Wheat can capture nitrate to a depth of 4 to 6 feet, reducing nitrate movement to groundwater.

4. The increased crop residues accompanying biosolids application can reduce wind and water erosion.

**Matching biosolids nitrogen to crop needs**. Much of the total nitrogen provided by biosolids is not available to plants. The portion present in the ammonium form can be volatilized at application. The organic N in biosolids must be mineralized to plant-available forms (ammonium and nitrate) before plants can utilize it.

Matching the amount and timing of plant-available N released from biosolids is important from a crop production point of view. Recent research in the 10-14 inch annual precipitation zone in central Washington State (locations near Waterville and Ritzville) showed that rates of approx. 300 lb total N/acre as biosolids provided more than enough plant-available N for maximum grain yields (Sullivan et al., 1995). Higher biosolids application rates (> 300 lb total N/acre) reduced grain yield and quality via lodging, grain shrivel, and increased grain protein.

Availability of biosolids N is also important from an environmental point of view, because excess N that leaches below the root zone is a wasted resource, and may become a groundwater contaminant. Biosolids producers (wastewater treatment plants), farmers, and regulators all need good estimates of biosolids N availability to develop sustainable biosolids management programs.

## OBJECTIVES

The long-range objectives of our study with biosolids are to:

1. Measure the availability of biosolids N (plant-available N/dry ton)
2. Determine the residual soil fertility effects of a one-time biosolids application
3. Determine the value of biosolids for dryland soft-white winter wheat production

This preliminary report addresses nitrogen availability only.

## MATERIALS AND METHODS

This report includes only the fallow year data from one field location (Pinkerton Farm) in Sherman County. We plan to collect data at two sites from biosolids application to harvest. The Pinkerton site is situated on a Walla Walla silt loam soil, about 3 miles north of Moro (just west of Oregon State Hwy. 97). Soil depth varies from 3 to 6 + feet. Individual plot size is 40 x 300 ft. to accommodate biosolids application equipment and combine harvest.

Treatments at each experimental site include a 3 x 2 biosolids rate x application date factorial, an anhydrous ammonia control (grower rate of about 50 lb N/acre), and an unfertilized control with three replications. The biosolids rates are designed to supply a range of plant-available N rates. The biosolids application dates in our study (6 Nov. 1995 and 22 Apr. 1996) represent the most feasible application times for biosolids in a wheat-fallow cropping system (fall after crop harvest and spring of summer fallow year).

Unified Sewerage Agency (USA) of Washington County, Oregon supplied the biosolids used in our study. Biosolids from primary and secondary wastewater treatment were anaerobically-digested and dewatered at the Rock Creek plant in Hillsboro. The USA treatment process uses alum [$Al_2(SO_4)_3$] to precipitate additional phosphorus from the wastewater during the summer months. This alum was a component of the biosolids we applied in November, but was not present in the biosolids we applied in April. Characteristics of USA biosolids are shown in Table 1. The biosolids contained about 17 percent dry matter and 83 percent water as spread. Biosolids pH was 8.0, favoring rapid ammonia loss after application. Biosolids were applied via a rear-delivery manure spreader equipped with a hydraulic ram. The biosolids in each spreader load were weighed using portable weigh pads. Biosolids were not incorporated into the plow layer immediately after application. The interval between application and tillage was about six months for the fall application and about a month for the spring application.

We collected composite soil samples to a depth of 36 inches on 25 June 96. The sampling took place about a month after the initial fallow tillage. Each composite sample consisted of 20 cores from the surface 12 in., and 5 cores from the 12-24 and 24-36 in. depths. We measured inorganic N ($NH_4$-N + $NO_3$-N) at all depths.

## RESULTS AND DISCUSSION

Most of the ammonium-N present in the biosolids at application (Table 1) was probably volatilized (lost as ammonia gas) before the first tillage.

Table 1. Average biosolids analysis for 1995-96 at Unified Sewerage Agency's Rock Creek wastewater treatment facility (Hillsboro, OR).

| Element | lb/dry ton |
|---|---|
| Total nitrogen (N) | 103 |
| Ammonium-N ($NH_4$-N) | 14 |
| Nitrate-N ($NO_3$-N) | 0 |
| Phosphorus (P) | 54 |
| Potassium (K) | 4 |
| Sodium (Na) | 1 |

volatilization is very rapid from dewatered biosolids because their pH is near 8. Volatilization of 50 to 80 percent of the biosolids ammonium-N is expected during the first week after application.

Biosolids application increased soil profile inorganic N (Table 2). The amount of soil inorganic N recovered increased with the amount of biosolids applied. A dry ton of biosolids supplied an average of 17 pounds of inorganic N. For biosolids applied in the fall, most of the N recovered was in the nitrate form. For spring-applied biosolids, most of the inorganic N was in the ammonium form. Both nitrogen forms have the same value for plant uptake. Ammonium-N will be converted to nitrate by soil micro-organisms.

Recent research in the 10-14 inch annual precipitation zone in central Washington showed that soil inorganic N recovered shortly after biosolids application was about 50 percent of that recovered during the two-year wheat-fallow cropping cycle (Cogger et al., 1997). Therefore, we expect additional

Table 2. Plant-available nitrogen (0 -36 in. depth) recovered during summer fallow. Pinkerton Farm, Sherman County

| Nitrogen Source | Biosolids Rate | Application Date | Soil sampled 25 June 96 (in fallow) | | | |
|---|---|---|---|---|---|---|
| | | | $NO_3$-N | $NH_4$-N | $NO_3$-N + $NH_4$-N | |
| | dry ton/acre | | lb/acre | lb/acre | lb/acre | lb/dry ton |
| None | 0 | | 19 d[1] | 26 d | 45 c | |
| None | 0 | | 18 d | 28 cd | 47 c | |
| Biosolids | 1.4 | 06-Nov-95 | 36 bc | 31 bcd | 67 b | 16 |
| Biosolids | 2.3 | 06-Nov-95 | 45 b | 33 bcd | 78 b | 14 |
| Biosolids | 4.4 | 06-Nov-95 | 83 a | 46 b | 129 a | 19 |
| Biosolids | 1.6 | 22-Apr-96 | 34 c | 46 b | 80 b | 23 |
| Biosolids | 2.4 | 22-Apr-96 | 32 c | 45 bc | 77 b | 13 |
| Biosolids | 4.5 | 22-Apr-96 | 37 bc | 81 a | 118 a | 16 |
| Biosolids average | | | | | | 17 |

[1]Numbers within a column are significantly different at $P < 0.05$ via protected LSD. Soil testing performed by standard methods at OSU Central Analytical Laboratory.

inorganic N to be mineralized from the biosolids as our study continues.

**Future.** This is the first year of our biosolids study. Nitrogen recovered during the summer fallow after biosolids application was similar to that observed at dryland locations in Washington. Grain yield results and additional soil data will soon be available from the Pinkerton site. We applied the same treatments to a second site in Sherman County in fall 1996/spring 1997. When our study is completed, it will assist biosolids producers (wastewater treatment plants), farmers, and regulators in making the best use of biosolids in dryland agriculture.

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